TECHNOLOGY MANAGEMENT, Inc.

526 20 1/4 Road   -:-   Phone 303-242-6154
GRAND JUNCTION, COLORADO 81501

ENGINEERS   CHEMISTS

Plateau Engineering, Inc.   November 8, 1978
840 Rood Avenue   TMI/PEI 78-2
Grand Junction, CO 81501

Attention : Mr. Edward Carpenter

Subject : Vanadium Queen Mine

Dear Mr. Carpenter :

Regarding the mine drainage water from the above property, I have further
investigated the hydroxide precipitation of the objectionable ions, as
opposed to barium sulphate precipitation, as you requested. The results
are discussed below.

It was thought necessary to investigate hydroxide precipitation because of
the potential economic advantage to be realized; 1 to \$3 / day chemical cost
versus 6 to \$7 / day for the barium sulphate process. It should be pointed
out, however, that the cost used for the barium process was for the maxi-
mum treatment, limited by chlorides in the effluent, and has not been opti-
mized in any way. Also, the question for what the official stance will be
towards NH_3 in the effluent from the hydroxide process has not yet been
resolved.

Ammonium hydroxide was chosen over sodium hydroxide for the following rea-
sons:

1). The sodium hydroxide precipitates are very messy and slimy, the
     ammonium precipitate is not.

2). Arsenic is not at all reduced by sodium hydroxide but does end
     up in the precipitate when formed by ammonium hydroxide.

3). At the conditions of treatment 5.0 to 8.0 pH, the radium is not directly precipitated at all, but is strongly adsorbed on ferric hydroxide floc. As the presence of trivalent iron is necessary for the removal of arsenic and selenium, the ferric hydroxide process, using ammonium hydroxide and ferric sulphate as starting chemicals, was the one chosen.
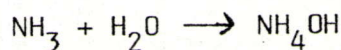
Samples of the water in question were obtained and some preliminary tests were done. Based on the low buffering capacity of the water, a dosage of 200 ppm $Fe_2(SO_4)_3$ with a stoichiometric amount of NH_4OH was chosen.

$$6NH_4OH + Fe_2(SO_4)_3 \longrightarrow 2FeOH_3 + 3(NH_4)_2SO_4$$
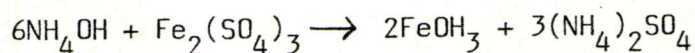
Formula wt.   =   210 + 399.7

Ratio   =   1 : 1.90

For 200 ppm $Fe_2(SO_4)_3$, would require $\dfrac{200}{1.90}$ = 105.26 ppm NH_4OH.

$$NH_3 + H_2O \longrightarrow NH_4OH$$

Formula wt.   =   17   18   35

$\dfrac{17}{35}$ x 105.26 = 51.13 ppm NH_3

Flow rate from mine = 2.5 GPM = 9.46 LPM = 13627 L/D

$$Daily\ NH_3 = \frac{13627 \times 51.13}{1000 \times 454} = 1.53\ lbs/day$$

$$Daily\ Fe_2(SO_4)_3 = \frac{13627 \times 200}{1000 \times 454} = 6.0\ lbs/day$$

Daily chemical cost :

$Fe_2(SO_4)_3$ cost = 6 lbs x $0.11   =   .66

NH_3 cost   = 1.53 lbs x $0.35 = .54

$1.20 TOTAL/DAY

As per your request, a one gallon sample of the Vanadium Queen water was treated in our laboratory with the above 200 ppm $Fe_2(SO_4)_3$ dose and sent out for analysis along with a one gallon sample of untreated water.

Treatment : Starting pH on the water was 7.5. The required amount of ferric hydroxide was added first, which lowered the pH to 5.65. The required amount of ammonium hydroxide was then added and the pH returned to 7.5. The sample was stirred and allowed to settle for 10 min. (the top 0.5 cm had settled clear). The sample was restirred and allowed to settle for one hour (the top 16 cm had settled clear). The sample and the blank were then filtered and bottled for shipment.

The results were as follows :

	Untreated		Treated	
Uranium	1.06	ppm	0.36	ppm
Arsenic	0.17	"	0.00	"
Selenium	0.00	"	0.00	"
Ammonia	0.26	"	26.80	"
Dissolved solids	324.0	"	322.0	"

The results are about as expected. Due to the time required and the expense involved, radium was not tested for, but based on theory, the reduction should have been at least 90% of the amount present. Increasing the treatment dosage from that recommended above should increase the removal efficiency, but will of course, also increase cost and ammonia residual in the effluent.

As far as a treatment system goes, the ferric hydroxide can be pre-dissolved in water and fed with something like a Clarkson feeder. Due to the corrosive nature of the chemical, this part of the system should be all plastic. The ammonia can be fed from the cylinder as a gas, using a pressure regulator and a rotameter. Carbon steel or plastic will do well here.

The chemicals can be fed into a turbulent flow section of a ditch leading to the ponds, the ferric first and then the ammonia further downstream. A small pump could draw old sludge from the bottom of the pond and add it to the incoming water a short distance ahead of the pond for a reseeding action. This will speed up settling.

If flow rates are steady, there will be no need to have automatic control on the chemical feeders; just measure the flow, chemical rates and pH a couple of times a day. An inexpensive recording pH meter would, however, be a great help in operating this system.

If I can be of any further help in this matter please call.

Very truly yours,
Technology Management, Inc.

Carlon C. Chambers

Carlon C. Chambers, P.E.
President

P.S. Attached are copies of other reference material that I found.

cc : file
CCC/klg